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THE ÆTIOLOGY OF EPIDEMIC INFLUENZA
A CRITICAL REVIEW

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THE recent and widespread outbreak of epidemic influenza has been the occasion for very extensive research regarding the cause of this disease. In many places the clinical material was only available during a short local epidemic and for this reason the preliminary experiments were often intensive and not fully developed until the epidemic had passed. The present time, therefore, would appear to be favourable for reviewing the more important results of these investigations.

Epidemic influenza is notably a pandemic disease and manifests itself by an unusual number of clinical conditions. In the recent literature there have been excellent descriptions, both clinical and pathological. The more severe form was the acutely fatal influenzal pneumonia. The lungs of these cases presented pathological findings that have only been seen during epidemics and were recognized as typical of epidemic influenza. There were, however, during these periods cases of all degrees of severity, the mildest showing only acute fever, headache, general pains and weakness for a few days, and having no lung involvement. These milder cases were considered to be epidemic influenza because they occurred during these periods. But until a causative agent has been found for both mild and severe forms it will be impossible to decide whether or not they are manifestations of the same disease. The clinical pictures of the milder types are seen in non-epidemic years and yet they are not diagnosed as epidemic influenza. No doubt sporadic cases continually occur—the virus must in some way be maintained between epidemics—but such cases can not at present be recognized with sufficient certainty to furnish experimental material. The ætiological agent must be sought in typical cases during epidemic periods. The sporadic cases can then be elucidated by demonstrating that they result from the same virus.

Two views regarding the nature of this virus have occupied the attention of most investigators. The first, originally advanced by Pfeiffer, regards *B. influenzæ* as the causative agent; the second, of more recent date, believes that the disease is due to a filterable virus. Rosenow, [1], [2] it may be added, has isolated a green producing *streptococcus* from cases of influenza and obtained experimental evidence which led him to believe that it is the cause of influenza. His work, however, has not been confirmed.

When considering these two views in detail

one has to keep in mind the conditions that must be fulfilled before one is justified in concluding any virus to be the cause of influenza. An admirable discussion of this point has been written by Fildes and McIntosh[3]. Briefly stated the conditions are those which Koch laid down for himself in his studies on the ætiology of tuberculosis. These are as follows:

1. The virus should be capable of being recognized in a large proportion of the cases of the disease, preferably in relation to the chief lesion.

This may be accomplished by staining the tissues, by cultivation on nutrient media, or by reproduction of the disease in animals.

2. The virus should be shown to be living. This may be demonstrated either by growing several generations of the virus, or by carrying out several animal passages.

3. The virus should be capable of reproducing the disease in other animals.

This condition offers several difficulties. The inoculation of the animal should be made with a pure virus. It is necessary to choose a susceptible species and a suitable route for the introduction of the virus. Should the animal become ill it is required to demonstrate that the disease in question has been reproduced and to recover the virus from the diseased animal.

The demonstration of immune bodies, particularly agglutinins in the serum of patients is not to be considered as indicating that the agglutinated organism is the cause of a disease. The agglutination of *B. proteus* by the sera of typhus patients is a case in point. The presence of immune bodies, either in patients or infected animals, is, however, of considerable confirmatory value.

Filterable Virus

Several workers have reported negative results from the inoculation of volunteers and animals with filtered materials from influenza cases.

Lister and Taylor[4] sprayed the nasal cavities of fifteen men with filtered nasal washings from early cases.

Wahl, White and Lyall[5] inoculated six men with filtered extract of influenzal lungs by introducing it into the nose and naso-pharynx.

McIntosh[3] inoculated monkeys, rabbits and guinea pigs with filtered nasal washings, sputum and lung juice.

Keegan[6] and Roseneau[7] reported similar results.

Nicolle and Lebailly[8] observed symptoms of influenza in two volunteers inoculated subcutaneously with filtered sputum; also in two monkeys inoculated under the conjunctiva and by nasal instillation with the same sputum unfiltered.

Dujarric de la Rivière[9] was himself inoculated subcutaneously with filtered influenzal blood and afterwards had symptoms of influenza.

Such negative or indefinite results can hardly be regarded as more than suggestive.

The first extensive experiments supporting a filterable virus as the cause of influenza were reported by Bradford, Bashford and Wilson[10]; Gibson, Bowman and Connor[11]. The former described a minute, filter-passing organism which they found constantly in cases of influenza and which they were able to grow by special cultural methods. Inoculation of monkeys and guinea pigs with these cultures resulted in symptoms and lesions that were noted as typical of influenza in man. The organisms were recovered in pure culture from the animals.

Gibson, Bowman and Connor independently isolated an organism which both groups of workers considered identical with that described by Wilson. They produced "typical experimental influenzal lesions" in monkeys, rabbits, guinea pigs and mice by inoculating them with the cultures, and recovered the organism from the animals. The lesion regarded as typical was a peculiar type of hæmorrhage into the lung. This they were able to transfer from one animal to another by reinoculating the Berkefeld filtrate of hæmorrhagic lungs. The same lesions were seen in animals inoculated with blood and sputum from influenzal patients. Therefore the organism was considered to be the virus of the disease.

At a later date Bradford and Wilson in a note appended to a criticism of their cultures by Arkwright[12], retracted their claim that a filter-passing organism had been grown in pure culture and stated that degeneration forms of bacteria and protein particles in their cultures had been mistaken for such an organism. This retraction may also be applied to the work of Gibson, Bowman and Connor, for they state that they were in agreement with Capt. Wilson that their "organism" was the same as he had found.

Further light has been shed on the nature of the lesions found in the animals through experiments carried out in our laboratories[13], [14]. During the epidemic of influenza in Toronto early in 1920, guinea-pigs and rabbits were

inoculated with filtered material from influenza cases. None became ill but when they were killed a few days later approximately half of them had lung changes. These were of two types. The most striking lesion was hæmorrhagic. Sometimes the lungs were spotted with small areas of hæmorrhage 2 or 3 mm. in diameter, seen on the pleural surface and on section. In other cases they coalesced to form irregular larger areas that extended into the lung substance. The most extensive change involved the larger part of one or more lobes. No fibrin was seen. Congestion and hæmorrhages were occasionally found in the tracheal mucous membrane and the trachea contained frothy fluid.

Microsopically the hæmorrhage varied in extent. The smallest lesion was extravasation of red cells into the alveolar walls. In places this broke through the walls into the alveoli. Where it was most extensive the air-holding tissue was almost completely obliterated, a few empty alveoli standing out prominently in the midst of an area of solid hæmorrhage. Various grades of the same lesion were to be found in the same section. In places there was also œdema. In some cases the lumen of the bronchi contained red blood cells. Two striking features of the hæmorrhage were the absence of leucocyte reaction about it and the absence of hæmosiderin in the cells of the lung tissue.

The second type of lesion was proliferative. In the gross it could not always be detected. Microscopically it consisted of a thickening of the alveolar walls due to prolifieration of endothelial cells. Where the change was least, the outline of the alveoli could be easily traced but the air space of the lung was considerably lessened. In places of greater change, single alveoli were completely obliterated by the proliferation; others nearby were only a small fraction of their original size and the outline of the alveolar walls was lost in the diffuse mass of cells. Where this was most marked, the tissue was solid and the air space entirely obliterated. The cell masses included capillaries. Giant cells were occasionally seen. A recent thrombosis of a small branch of pulmonary artery was associated with this type of lesion.

Although some lungs showed only proliferation it was common to find hæmorrhage as well. The picture presented by the combination did not suggest that the two processes had a common cause or that one resulted from the other. Both the hæmorrhage and the proliferation occurred alone so definitely and so frequently that their association appeared to be accidental and could not be construed as signifying a more fundamental relationship.

By passing an extract of a hæmorrhagic lung through a Berkefeld filter and reinoculating the filtrate into another guinea pig we found that the lesions were reproduced in the lungs of the second animal. In one instance they were carried through seven reinoculations, in another series through six, and in another th ough five. By employing a special technique an attempt was made to obtain cultures of a virus from human and animal material but without success. Some of the cultures became turbid and showed very fine regular bodies much smaller than bacteria and very difficult to stain, but the same features appeared in cultures of control material. Although none of these cultures contained ordinary bacteria, guinea pigs inoculated with them showed the typical lesions.

The hæmorrhage was undoubtedly the most singular and striking lesion in our animals and corresponded to that described in the articles already mentioned[10], [11], as typical of "experimental influenza" in animals. One of these authors[11], who examined our specimens in our laboratory, agreed with us that they were the same lesions as they had obtained.

After the Toronto epidemic had subsided we incolulated a series of guinea pigs with control material from healthy patients who had not had influenza. The animals were killed after a similar interval. In their lungs exactly the same lesions were found, and in the same percentage as after inoculation with influenzal material. We then killed some healthy guinea pigs from our stock pens,—pigs that had never been inoculated. They too showed the same pulmonary lesions; and in order to determine if some condition peculiar to our pens was responsible for their production, guinea pigs from another laboratory were killed, with the same result. In view of these controls it was quite apparent that the animal lesions had no connection with the infective agent of influenza.

Further experiments[14] were made in an endeavour to explain their causation and resulted in demonstrating that the hæmorrhage was an agonal phenomenon due to the method of killing. Our routine had been to give the animal a blow on the back of the head. It was shown that hæmorrhages did not occur when the guinea pigs were killed by a sudden incision with sharp

pointed scissors which opened the chest wall and the ventricles of the heart with one snip. But they did occur, in a small percentage of animals killed by bleeding from the vessels of the neck or by rapid chloroform anæsthesia.

The histology of the proliferative lesion showed it to be essentially a slow inflammatory proliferation of endothelial cells. The exact ætiological agent was not determined although there were some reasons for suggesting that it might be due to *B. bronchisepticus*.

The lesions described by Bashford, Bradford and Wilson; Gibson, Bowman and Connor, have thus been accounted for. They were evidently not the result of the virus of epidemic influenza and one is not able to deduce from their experiments that such a virus is a filter-passing organism.

Similar lesions have been obtained by others and advanced as evidence of the operation of a filterable virus. Major Milton W. Hall[15] inoculated filtered sputum from influenza cases into rabbits, guinea pigs and mice. The animals showed no uniformity of clinical symptons and many remained in perfect health. They were killed by a blow on the back of the neck. The lungs showed hæmorrhages, the description of which corresponds remarkably in its details with that which we have given above. The hæmorrhagic areas were regarded as undergoing organization resulting in irregular masses of large mononuclear cells, in some places retaining the outline of the alveolar walls. The photograph of this "carnification of thickened alveolar walls" is undoubtedly the proliferative lesion that we have described. The lesions were transferred through as many as nine animal passages by reinoculation of lung emulsion. However, when viewed in the light of the possibility that the lung changes were agonal phenomena or a spontaneous animal disease, there would not appear to be any evidence in them to indicate that a filterable virus is the cause of influenza.

Olitsky and Gates, in a series of papers[16,17,18,19], have reported experiments made during two epidemics and the period between. They inoculated rabbits intratracheally with filtered and unfiltered nasal washings obtained from cases of influenza during the first thirty-six hours of symptoms. In the absence of bacterial infection no animals died. They were killed by a sharp blow which dislocated the cervical vertebræ. The respiratory organs only were affected. The typical pathological change consisted, in the gross, of hæmorrhage, œdema and emphysema. The appearance of the hæmorrhagic areas was like the typical lesion we have described. Microscopically the lungs showed foci of hæmorrhage, œdema and emphysema. The aveolar strands were infiltrated with large cells of a foreign nature. Although mononuclear cells were seen in the alveoli and interalveolar walls there does not seem to have been any prominent leucocytic reaction. The œdema appears to have been greater than in our lesions but on the whole there is a striking resemblance between these lungs and those we have described. A comparison of our sections with those figured by Olitsky and Gates[18] shows a picture almost identical with that which we have obtained in control animals and by special methods of killing, and we do not feel that these lesions are characteristically similar to those found post-mortem in epidemic influenza in man.

By reinoculating affected lungs the lesions were transferred through several animal passages, rabbits and guinea-pigs being used. They found that washings from patients later in the disease produced lobar consolidation, when any lung changes were found. Control animals inoculated with washings from non-influenzal cases did not show the "familiar clinical and pathological action". A few developed lobar pneumonia and others gave "inconstant effects".

Blood changes were also observed. The change corresponding to the typical hæmorrhagic lung condition was a leucopænia largely due to decrease in the mononuclears. The lobar infections were associated with a polymorphonuclear increase and the unaffected lungs were not accompanied by any great change.

In a later communication[20] small bodies were described which appeared in anærobic cultures of influenzal material and which passed through a Berkefeld filter. Animals inoculated with these bodies showed a leucopænia, a decrea e in mononuclear cells, and at autopsy the typical lung lesion.

To what extent this evidence warrants one in concluding that these bodies are the virus of influenza and that the typical clinical and pathological changes in the animals are due to the operation of this virus is a matter for discussion. The typical pulmonary lesions bear a very striking resemblance to those described in our experiments, so great in fact that it seems probable that the method of killing has been a factor in producing them. By itself the leucopænia has no very great significance, at best such

changes are only corroborative evidence of reproduced disease. The culture and recognition of filterable organisms is open to many pitfalls and in the absence of any more definite evidence it would seem justifiable to wait for further confirmatory work rather than to accept at once this virus as the cause of epidemic influenza. But, from the fact that with inoculation of normal material and a definite method of killing the same hæmorrhagic picture was obtained by us, we are not inclined to accept either the observations of Olitsky and Gates or the English observers.

At the time of going to press, a preliminary report of experiments by Loewe and Zeman[36] has appeared. They have cultivated a minute filter-passing organism which they state does not appear to differ from that isolated by Olitsky and Gates. The cultures were obtained from nasopharyngeal washings of influenza cases. Rabbits inoculated intratracheally were killed after one or two days and showed "characteristic" lesions. Cultures were obtained from the rabbit lungs, and emulsions or filtrates of these lungs produced similar changes in other rabbits, several animal passages having been made. The pulmonary lesions were of the same order as described by Olitsky and Gates and so far as we can determine from the preliminary report, their experiments are open to the same criticism as we have applied to the work of Olitsky and Gates and the English investigators.

B. Influenzæ (Pfeiffer)

This organism was discovered by Pfeiffer in 1892 who advanced it as the cause of epidemic influenza because he recovered it in pure culture from many cases during that outbreak. He did not succeed, however, in reproducing the disease in animals. Further study of hæmoglobinophilic bacilli, of which Pfeiffer's organism was the original type, revealed a large group of organisms having the common property of requiring blood pigment for their growth. *B. influenzæ* formed but one type.

Pfeiffer recognized another group which he called pseudo-influenza bacilli. Davis[21] considers this to be a heterogeneous group, morphologically the same as *B. influenzæ*, the organisms of which have little else in common with one another except their hæmoglobinophilic property. They have been found in a variety of diseased conditions and in normal tissues.

Stillman and Bourn[22] investigating sputum from cases of influenza and pneumonia and the pharyngeal secretions of healthy people found typical *B. influenzæ* and pseudo-influenza bacilli which differed by having the property of hæmolyzing blood agar, the typical group causing no hæmolysis.

It is the typical *B. influenzæ* of Pfeiffer that has been considered by some to be the cause of influenza.

During the recent pandemic it was present in a large percentage of cases, associated with other pyogenic organisms. The latter were regarded as secondary invaders and chiefly consisted of *streptococcus, staphylococcus, pneumococcus, micrococcus catarrhalis and B. mucosus capsulatis.*

The percentage of cases in which *B. influenzæ* was demonstrated varied considerably both in different localities and in the same place at different times. This was also true of the secondary invaders, and for this reason some have regarded *B. influenzæ* as having the same relation to the disease—viz., a secondary invader following in the path of some specific virus which had primarily affected the respiratory organs.

However, it must be admitted that *B. influenzæ* has been demonstrated in relation to the chief lesions of the disease in a sufficiently large percentage of cases to warrant one in considering it as having fulfilled the first requirement of Koch's postulates. The fact that it occurs in other diseases and may be present in normal throats during epidemic periods or between them, and that it is present in a varying proportion of influenza cases, do not in themselves rule out the possibility that it might be the cause of the epidemic disease.

The most important evidence, however, comes from inoculation experiments.

Probably in no other connection have so many volunteers offered themselves for the investigation of disease.

Roseneau[7] sprayed the nose, throat and eyes of nineteen men with an emulsion of living *B. influenzæ* containing thirteen strains, some of which had been recently isolated from lungs of fatal cases. None of the men became ill.

Lister and Taylor[4] introduced into the mouth and nose of nine men, living suspensions of three stock strains of *B. influenzæ*. All but one remained well and his illness could not be considered as an attack of influenza.

Wahl, White and Lyall[5] inoculated five volunteers with large doses of four strains, one being

the first subculture from a fatal case. None of the men became ill.

Yamanouchi, Sakakima and Iwashima[23] sprayed pure cultures of *B. influenzæ* and mixed cultures of the common cocci into the nose and throat of fourteen healthy people and did not cause any illness.

Sellards and Sturm, and Bloomfield have also reported negative results.

Cecil and Steffen[24], on the other hand, inoculated the nose and throat of six volunteers, who became ill. Two were given massive doses of saline suspensions from agar, two received peritoneal exudate from a monkey, and for the last two a blood broth culture was used. In each case an upper respiratory infection was produced. Considering the size of the doses the saline suspensions caused surprisingly mild infections; the growth from one chocolate agar slant was used for one patient and that from two slants for the other. Smaller doses of the fluid cultures gave better results. The local symptoms resembled an acute coryza and were more striking than the constitutional disturbance. "The systemic reaction in the experimental disease was not so profound as in true influenza and resembled more the prostration that accompanies a severe cold or bronchitis." The absence of fever in the cases was also unlike epidemic influenza. The authors conclude that "virulent bacilli, when injected into the nose and throat of healthy volunteers, may excite in them an acute respiratory disease similar in many respects to influenza, but falling short of the typical clinical picture."

Thus attempts to reproduce epidemic influenza in man with *B. influenzæ* have been markedly unsuccessful and the results suggest very strongly that this organism is not the primary cause of the disease. There is general agreement, however, that it played a part in producing the pneumonias, but in the light of these experiments it would appear to have been present as a secondary invader.

Blake and Cecil[25], [26] have worked extensively with animals. Two groups of monkeys were inoculated,—one group by way of the nose and throat, the other by intratracheal injection—with a strain of *B. influenzæ* from an empyema following influenzal pneumonia. Its virulence was increased by passage through eleven mice and the peritoneal cavity of thirteen monkeys before it was used for the experiments.

The question arises as to what findings one would require in the animals, as a result of inoculation, to support *B. influenzæ* as the cause of the disease in man. In animals clinical signs are suggestive but in themselves not conclusive. Decisive evidence would come from the character of the pathological changes in the respiratory organs and the association of the ætiological agent with them. As a standard of lung lesions to be expected from *B. influenzæ* there are on record [27], [28] the descriptions of human lungs from patients who have succumbed to a pure infection of this organism.

The first group of animals consisted of twelve monkeys which received as much as 3 c.c. of a blood broth culture or peritoneal exudate from another monkey. Signs of upper respiratory infection followed, in five complicated by acute sinusitis. None of the animals died. Nine were killed in from three to six days. At autopsy three showed bronchopneumonia, from two of which *B. influenzæ* was recovered. But the organism was also recovered from three without pneumonia, although two of these had tracheo-bronchitis.

The second group comprised eleven monkeys inoculated intratracheally. Five received massive doses, the growth from our four or five plates having been used for each animal. They were killed in from two to six days. Four had bronchopnuemonia, but only two yielded cultures of *B. influenzæ*. Cultures from the other two were sterile. The fifth monkey showed tracheobronchitis but no pneumonia. As a control a massive dose of killed organisms was given to the sixth monkey. It was killed on the sixth day and showed bronchopneumonia. The remaining five received the growth from one plate or the equivalent amount of peritoneal exudate from another monkey. They were allowed to live for from one to seven days. Three had bronchopneumonia, two of which yielded no *B. influenzæ*, the other giving a culture from the bronchus. The fourth had tracheo-bronchitis and sterile cultures, and the fifth did not become ill.

When these results are analyzed for evidence capable of being applied to the elucidation of the ætiology of influenza in accordance with the foregoing discussion, it is seen that only three animals had a bronchopneumonia associated with *B. influenzæ*. The monkeys inoculated with massive doses cannot be included in the evidence because a similar dose of dead organisms also produced bronchopneumonia. Six animals with lung lesions yielded no *B. influenzæ* and on this account cannot be considered as satisfactory evidence,

although it was possible that the organisms had died out.

The bronchopneumonia of the three animals, shown by culture to be due to *B. influenzæ* was compared with post-mortem lesions of human lungs in which a pure *B. influenzæ* infection had occurred. There was agreement in some particulars but the pictures were not the same. Because of this discrepancy and in view of the lung changes without associated organisms, and the production of bronchopneumonia by killed bacteria, the value of the experiments has been somewhat impaired. The experimental method has considerable merit, as shown by the clear out transference of measles to monkeys which has recently been reported[29], so that if *B. influenzæ* had been the virus of influenza one would have expected more decisive results than were obtained. A bronchopneumonia was initiated by *B. influenzæ* which in some respects resembled the human lesions but it is not possible to conclude from the experiments that this organism is the cause of epidemic influenza. In fact the authors themselves do not make this claim.

The theory has been advanced that a special strain of *B. influenzæ* with a markedly exalted virulence might have accounted for the epidemic. That variations exist has been demonstrated by several observers.

Cohen[30] found that strains from meningitis differed in agglutination and protection experiments and produced a fatal septicæmia in rabbits.

Stillman and Bourn[22] have made cultural distinctions in the production of indole and the fermentation of saccharose.

Recently in this laboratory two strains of *B. influenzæ* have been isolated from the same patient, one from the sputum the other from the lung at autopsy. The former was a coccoid bacillus, fairly uniform in size and shape, the latter a slender bacillus whose length was 1·5 to 4 times the width. The difference in morphology definitely indicated that the organisms wer not alike and this was further borne out by agglutination. An immune rabbit serum prepared from a third strain, having a titre of 1 in 2560 for the homologous organism, agglutinated the autopsy strain in a dilution of 1 in 1280 and failed to agglutinate the sputum strain in a dilution of 1 in 20.

Thus the finding of *B. influenzæ* in sputum should be controlled whenever possible by culture at autopsy since the strain in the sputum may not be identical with the one obtained from the diseased tissue. As the latter organism is the one likely to be taking part in the infection the culturing of sputum only, may lead to inaccurate conclusions.

Bell[31] has noted three main morphological types, the two we have just mentioned and a third, consisting of fairly long slender straight or curved bacilli with pointed ends, which we have also seen. These types did not correspond to agglutination groups. In one case two strains, isolated from one plate, differed in morphology but were identical by agglutination tests. In another case three strains isolated from the same plate differed in both morphology and agglutination. Most of his strains were not alike and he concluded that the group is heterogeneous but that identical strains do occur.

Valentine and Cooper[32] in Park's laboratory did agglutination and agglutinin absorption tests on 171 strains with 25 sera and could not detect any serological relationship by this means. Continuing this work in the same laboratory Povitsky and Denny[33] obtained similar results. They found that 185 strains from influenza cases were almost unrelated, five being the largest number to fall into any one group. Some meningitis strains had more in common, four out of seven belonging to the same type.

Cocoa and Kelly[34] have confirmed the r sults of Valentine and Cooper. The argument has been advanced by Park[35] and his assistants, supported by Cocoa and Kelly, that if *B. influenzæ* had been the primary ætiological agent a pandemic strain would hav existed, and therefore organisms obtained from cases in different places and at different times would have belonged to one type as revealed by agglutination tests. But the results did not reveal any such pandemic strain and therefore they belive the conclusion is warranted that *B. influenzæ* is not the primary infecting agent.

Summary

At present we believe there is not sufficient evidence to indicate what is the cause of epidemic influenza. There is no experimental certainty that the yirus is a filter-passer. The experiments which favour this view have been criticized in the light of results obtained in this laboratory.

B. influenzæ i undoubtedly present in a large but varying percentage of cases, and is a factor in producing the pathological complex of the disease. However, the failures to inoculate man

form impressive evidence that it is not the primary infecting agent. The failure of animal inoculation and the absence of a pandemic strain are further facts in support of this view. The evidence favours the opinion that *B. influenzæ* is a secondary invader.

The difficulties of making any advance in the problem arise mainly from the want of exact knowledge as to the *essential* lesions of the milder forms of epidemic influenza, and therefore of the lesions in animals which would indicate a reproduction of the disease.

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MEDICAL ORGANIZATIONS IN ONTARIO AND THE PRESENT NECESSITY

ANNUAL ADDRESS OF THE PRESIDENT OF THE ONTARIO MEDICAL ASSOCIATION

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IN appearing before you at this time I am expected to unburden my soul, and cause you to suffer as you bear with me until this effort is completed. In those matters in which we differ, I crave your indulgence. Throughout the past year I have had to sail the treacherous sea of public opinion and have endeavoured to play my humble part in guiding the ship between the extremes of reactionary and radical opinions. How to be progressive and not too radical for the present age, is indeed the question. I agree with the words of a popular author of the day, "But one-third of the population of the world is yet civilized. Centuries hence a unified civilization may complete the circle, but human nature and progress must act and react a thousand times before the earthly millenium, and it cannot be hastened by dreamers and fanatics." In pursuance of the time honoured custom, I intend to present for your consideration, a survey of social problems as they are to-day, of things which now, or may in the near future, affect us as a profession.

It is impossible not to recognize that the old world is being turned upside down. Probably it seemed ever thus to many. It is a great privilege to live in such an age when history is being written so quickly. We should admit that the great social revolution which has been prophesied, is already with us. That more or less unconsciously changes are taking place which may lead to even more radical changes in our social order.

The complexities of our civilization have a tendency to conceal our mutual interdependence. It is now just as imperative as it was in the primitive state, to obliterate individual selfishness, and demand of the present sane and modern elements of society, the recognition of their duties towards other members of the community. Should not the members of each group band together for efficiency of that service, which their group must render not only in their own, but in the interest of the public at large.

The medical profession as one of such groups has always been inspired by the highest ideals. In this process of re-adjustment it is certainly important that to-day we should have our eyes open and our ears to the ground. The question of complete care of health of all members of the community is definitely interlocked with all social questions of the day. As with them its proper solution must be arrived at without selfish class opposition on the one hand, or failure of co-operation through ignorance on the other.

Years of experience in daily service have given us a wide knowledge of social conditions and a sympathetic appreciation of the weakness of human nature, of the social as well as medical afflictions which come upon various members of the community. If we study the various conditions as they are presented, our profession can be of greater service to the community in the understanding of our problems in the new social order, than any other one profession or class, not excepting the clergy.

The older religions have laid emphasis on sacrifice. The test of one's faith has been one's willingness to make personal sacrifice; to give one's money, property, self and life to a cause. What the world needs most to-day is not sacrifice in the old sense but a complete rebuilding with the forces available.

We are in business to secure the means to live lives as full as our ability and ideals will permit, to get money to sustain ourselves and family and to have the means to protect us against the time of uncertainty in years to come.

In certain walks of life with the education available, men are prompted to apply their talents, not for service, but for the gain; even to be mere gamblers if more money can be obtained in that manner for their own pockets. There are too many parasites about us getting

their own profits from the efforts of other members of society and sucking or squeezing out of the public a living out of all proportion to their individual value to all the other members of society.

So long as many act entirely for themselves without regard for the rest of the community, society has not yet been organized to provide the best in life. The individual must learn that he who produces and serves in the interest of his neighbours will most surely reap benefit for himself.

Welfare work, charity and certain reform movements, in so far as they keep alive improper conditions, are negative forces. What the world needs most are the constructive forces which will find the remedy and this, in the interests of the whole human family. The instinctive sense of loyalty and obligation to one's own family needs to be expanded to embrace all mankind.

Men once looked to the past as the golden period of mankind. Then lived great men and good. Religions taught that we could be saved by turning thoughts back to those glorified days, and that salvation depended on believing. Our religion should also teach that salvation requires doing some practical work for the community. "Faith without works is dead." This applies to both the individual and the group.

What then is the duty of the medical profession in these stirring days? Who are we, and for what do we stand? By what authority can we even answer these questions? To what extent does our nominal organization represent our profession as a whole? Whose fault is it if it fails to speak for the many? How long will it be, before every unorganized member of our group will realize that as such, he is a menace to himself, a check on the progress of his class and a shirker in the battle of life.

It is now past forty years since the initial steps were taken in the matter of voluntary organization of the Medical Profession in this province. Circulars were sent to all local societies and many prominent physicians, asking for their opinions regarding the proposed organization. All endorsed the scheme, with one exception, and he feared that a Provincial Association would injure the Dominion Association. Thus we had in its very inception, the same bug-bear which is evident in another form to-day. A Provisional Committee was appointed in February, 1881, and soon after, the first meeting was held in the Spring of that year.

From this time until recently, the Association stood for little more than an Annual Meeting, an early summer excursion, an opportunity for amusement and social activities, with scientific discussions thrown in.

The various stages in our recent reorganization are well known to many, namely: the recognition of the local society and its affiliations in its representatives in the Committee of General Purposes, the division of the Province into Counsellor Districts, the Counsellors as members of our Board of Directors.

During the past year we have seen the advantage of calling together the members of the profession in eight of our Counsellor Districts, where scientific programmes of real interest were presented for their mutual advantage, on each occasion. Our experience during the past year amply justifies the advisability of continuing such Counsellor meetings as annual events, and making it possible in greater measure for all the members, and more especially their Executives and delegates, to receive information regarding the activities of the central machinery; to present suggestions or receive advice, and to take some active and real interest in the discussion of the many problems which are affecting our profession.

What are some of these problems?

Let us assume that we represent an intellectual class, and that our chief object in life is to provide a service in the interest of humanity of a highly specialized character.

Discussions regarding any revision of medical practice pass from the stage of apathy or scorn, to a violent and impossible opposition which too often savours of self-interest.

Should we not recognize that during the last two or three generations our plan for medical practice has not kept pace with changes in our social life? It is only fair to ourselves to admit that our plan for service to the community as a whole is incomplete and unsatisfactory in many respects. Some change is absolutely needed in the interest of the whole public body and is already at our doors.

As a remedy for such deficiencies, State Medicine has been proposed, as the perfect panacea. It may be necessary to admit that in the future of medical practice there must be more governmental control, both in the way of higher standards for admission into practice, and later even a continuous control for the maintenance of these standards. After careful study are we prepared to admit that any plan which has been

yet tried, or yet publicly suggested really supplies the need as we understand it at the present time?

"State Medicine" as we know to-day, it should rather be considered as a threat, not a solution, indicating what will happen to our profession if we quietly sit by and watch the activities of those who are outside our ranks; who without our aid, will surely establish some system which is unsound in principle and can never give complete satisfaction in practice. We have a right to demand that under all conditions, our standard of living should not be lowered from that which we, as a class, now enjoy. A sufficient opportunity for study and recreation should be available in any routine which may fall to our lot.

Under any system the aim must be to ensure to every individual in the community, a satisfactory medical service, without requiring him in time of great distress to accept charity or go into debt. He must be given every opportunity for exercising his unbiased judgment in the selection of his medical attendant, guided it may be by some standardization or reporting house system for our members in practice. He should not be so completely at sea as he now is. Too often the public makes selections on purely sentimental or personal grounds.

Just how much preventive work will be expected of the man in actual practice, or whether it is advisable to entirely separate these branches of service, is a question regarding which there are groups lined up on either side. Already we find examples of our so called Preventive Group overstepping the bounds in Child Welfare and Venereal Diseases. The treatment of Tuberculosis is almost completely out of our hands. I believe that a valuable opportunity will be lost, both to such communal branches of service, and to ourselves, if such are permitted to extend without our co-operation and interest.

We now have a strong committee known as the Committee on Interrelations of the Medical Profession and the Public, who as we know from their report, are studying the various suggestions already offered, and are keeping in touch with all current literature bearing on the subject of medical service in all its phases. Similar committees must be appointed in every local unit and machinery must be created whereby each is kept constantly in touch with information available on this subject in our Central Office. The meetings of such committees in our local units should be open to their membership at large and by means of Round Table discussions or otherwise, a greater interest and much useful discussion be thoroughly stimulated.

With such information before the profession, an intelligent understanding will be possible. We will have a large group of men prepared to represent our professional requirements when the legislators begin to take a hand.

A phase of state medicine is already with us, namely, the work under the Workmen's Compensation Act. There are too many of our members who are not satisfied with the treatment they have received. Some change is necessary in the plan of administration of this Act.

In the industrial world to-day, we hear from excellent authority that their are four parties to be considered in the bargain,—Capital, Management, Labour and the Public. Under the Workmen's Compensation Act we form a large portion of the Labour group, and as such, in their argument, we should have a very definite opportunity for expressing our opinions by having a regular representative on the Board, appointed by the Government.

In the meantime we know that a much better feeling would result under some system of intimate co-operation with this Board, whereby our Directors or certain other representatives appointed by us would act voluntarily in an advisory capacity. These could present complaints or assist in the adjustments of misunderstandings.

What about your dealings with Sick Benefit groups, the Lodges and other forms of contract work, including the great Industrial Corporations? Are the arrangements which they make with the individual members always fair to these, or is it a case of competitive buying in the cheapest market? We should certainly have some minimum standard for the guidance of those who wish to undertake this kind of work, not only in this province, but anywhere in our Dominion. The present Life Insurance fees are a sufficient example of this without further comment. These and other problems have been more fully dealt with in the reports of various Committees of our Association.

We will have no right to demand a hearing unless we are prepared to show that we are in a position to render service, and to guarantee the best service possible under varied conditions, we must clean house from within. We must not only correct or remove the cause for inefficiency amongst ourselves, but undertake a reasonable degree of education of the public

along the lines of the most modern scientific developments if we are to receive their complete co-operation in the maintenance of our standards and ideals.

Education must always be the first essential in any plan for the improvement of medical service for the public. The science and practice of medicine is ever changing. Advances in methods of diagnosis and treatment should be made available for all members of the community through the individual doctor in each particular case.

The profession can be kept in touch with these advances by means of the literature of the day, by frequent scientific meetings in large or small groups. A good library and an active society in each community is an asset in favour of the public. The real value of this cannot be represented in dollars and cents.

In many communities it is impossible for the medical man to leave his work in order to make himself more proficient, not only in latest advances in the elementary sciences, but in ordinary clinical routine work. We have attempted to offer a solution by making available in each County Society or local unit, post-graduate lectures direct from our universities.

As a profession, we must sympathize and co-operate with those who at great personal sacrifice of time and energy, have done so much to upbuild our great medical teaching institutions, for the benefit of those who are merely students, preparing themselves for their life work.

Having received assistance from the public funds for the development within their own walls, it is only fair to ask that their experts devote at least a small portion of their time each year for the benefit of the profession in practice and through them, the community at large in various parts of the province.

It is hoped that further demands will be made by each of our local units; that they will insist on their rights and through whatever means possible, persuade those who supply these funds to still further increase the opportunity for this service.

Surely the Government of this province has reached the stage in its development when it must pay more attention to the providing from the public purse, for greater assistance for this higher education. Many branches of teaching must be developed along special lines and true research encouraged. Adequate salaries must be paid to all the workers in all departments, and it should be unnecessary in this democratic age to look with longing eyes to the possible periodic munificence from our plutocratic benefactors.

Our post-graduate courses and teaching must not stop with didactic lectures on strictly scientific subjects. These must be extended to hospital wards wherever clinical material is available.

Our hospital beds must be increased in number. Patients no longer find it convenient or possible to remain in their homes. The question of shortage of nursing aid, both fully trained or otherwise, or even domestic help, drive many to hospitals who would have preferred to have stayed at home. Many problems in careful diagnosis and treatment whether medical or surgical, can only be properly taken care of in a well organized hospital.

We must make provision to elaborate an extensive hospitalization programme, which will take into consideration the actual needs in all of our small communities. It should be unnecessary for many of the patients and their friends to travel miles from home to some famous clinic, often at great expense and personal risk or injury. Each of these community hospitals should be thoroughly standardized according to a minimum plan.

Those interested directly in the administration of such Hospitals should not be satisfied until all members of the community where they are located, will have the privilege of, and reason for a complete confidence in the work conducted therein.

A plan for hospital standardization has been developed which depends on the following features: (a) Careful preparation and care of all scientific records. (b) Complete laboratory service to assist in this. (c) Careful study of such records by the group of medical men attending each institution.

The study of these records, in an impersonal manner, will supply an abundance of clinical material not otherwise available. This plan of hospital standardization is no fairy story or fantastic dream, but is in actual operation in scores of institutions on this continent to-day. This does not seem much to ask when the interests of the public are vitally concerned.

This community hospital becomes the health centre of the district, the place of meeting for the local practitioners, a democratic and unselfish group clinic wherein we can continuously provide a system for the development of the general

man along scientific lines. It may even be necessary in some of our communities to take active measures to re-establish in the public confidence, "the doctor of the old school" the Dr. McClure type, in "The Bonnie Briar Bush." This man knew the various members of the family, their most intimate personal affairs, from the cradle to the grave. No change in medical practice for the sick can possibly find a reliable substitute, provided we can keep him up-to-date.

In the development of our present machinery for preventive measures, our public health departments, every inducement should be offered to interest the majority of the general practitioners in all communal work. Their association with such activities would increase their interest in their routine work as it effects the individual in their practice. They would have unlimited opportunity for education of the public in all measures which may be formulated in the interests of the public. We are now only beginning to touch the fringe of future possibilities.

The elaboration of this plan for standardization to include diagnostic clinics, would remove the possibility of many unnecessary operations or treatments, and in other instances render valuable services to the community.

A consultant staff will undoubtedly be necessary in many forms of work, These may be developed within the group, or may be brought in as occasion demands from a larger centre. Such consultants, either in their communal or private work, should always be ready to render expert service when required by their brethren, and not so completely concerned with commercial advantages as too often we find many of the so-called specialists of to-day. The buying and selling of patients, otherwise called "fee splitting" is another example of commercial enterprise and should be prevented by some amendment to the Criminal Code. The taking of any part of fees by any system of secret graft, without actual service rendered, and without the knowledge of the patient, should more properly be called "theft".

If the specialist is not too busied with an egotistical appreciation of his own importance, he should recognize the part which the well trained general man takes in the community—services more valuable on critical occasions than any money can repay. The honest consultant should use every possible opportunity for assisting the public to properly understand the value of such services, and to pay a reasonable honorarium for the same. The real consultant should recognize his continuous duty in this education propaganda. In the future many of our now so called special procedures will become routine with all general practitioners.

Over specialization has been tried across the Border to the south, and has been found wanting. The best elements of their public are doing some thinking, and resent having to call in ten or fifteen specialists at once or at various times in order to have efficient routine care of their families in the simplest form of illness.

The six-weeks' specialist, or the bumptious novice, who soon after graduation decides to limit his field to some specialty, has been a serious factor in unsettling the public mind, and prevents their real appreciation of medical progress. His methods are much too common. He applies his various tricks in trade, his unnecessary fire-works, his private clinics to the family circle of the unfortunate patient, his sneers and jibes regarding methods of his neighbours in the profession, and all for the advancement of his personal prestige.

Let the rank and file of our profession stand by and use every possible effort to crush out of existence for all time, any educational programme which has for its sole object the creation of such as these. We can eliminate many of such by a prolonged supplementary course of training which should be sufficiently long to moderate their present exuberance and add wisdom to knowledge.

In making plans for the extension and perfection of our plan of organization, we must not forget those who are still students at our Universities. In our activities during the last two or three years, we have found it difficult to interest certain members of our profession who are well advanced in years. On the other hand the younger members of our progession have responded almost unanimously. We should extend our propaganda for organization to students, particularly those in the graduating classes. They should have some practical initiation into the problems of organization, and the duty that they owe, not only to themselves, but to the public at large, in maintaining our standards and ideals; and should understand their obligations as they go out into practice, to observe as rigidly as possible our principles of ethics.

A visit to the offices of the American Medical Association in Chicago would be full of interest and would prove to you what it has been possible to accomplish with perfection of organization and plenty of money.

They not only publish the Journal, but through various councils or committees carry on an intensive study of the many problems which are confronting them. The exposure of the fake remedies, the quacks and irregulars would fully justify our attempting to copy their huge machine. The public must be protected from those evils by a sane and effective educational propaganda, continuously supplied.

We must be prepared to extend the activities of our machinery of organization and the development of our central office. A much larger whole time staff must be engaged. The profession, either as individuals or acting through their organized units, must be prepared to subscribe liberally towards the funds which will be necessary. These matters are urgent and must receive our immediate attention.

Is it possible that any will refuse to play his part in the development of a policy which will further the advancements of medical knowledge, protect the public at large by prevention, and guarantee a complete medical service to all members of the community?

If we must appeal to ourselves on selfish grounds, let us remember the members of our own families not only as they are to-day, but as they may be, when we are gone, the men and women of the future with their families. Is this organization and educational propaganda not in their interests?

Uniformity is not essential for unity, but we can with efficient organization, assist in the fulfillment of our objects, and by co-operation and education more certainly guarantee the opportunity, rights and privileges of all of our individual members.

CARDIAC IRREGULARITIES

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In presenting this paper, an endeavour has been made to summarize the present day views of the important cardiac irregularities with a review and emphasis of the salient points in the differentiation and diagnosis of the various types.

The subject of cardiac irregularities and the diagnosis is an extensive one, the sites of origin and the various forms of irregularity and their causation being numerous and the exact diagnosis not always simple.

Irregularity in the heart's action is a frequent occurrence, readily recognized as such by the examining physician, and very often noted as being present by the patient. The irregularity may be a warning of mischief done, and of grave significance. Even more frequently, however, the irregularity is of no serious import. It is not so many years since the very presence of an irregularity in the heart's action served as an indication for all manner of restrictions being placed on the patient, and this very often without consideration of the nature and origin of the irregularity. It is therefore of importance that we should have a working knowledge of the various types of cardiac arrythmias, and of their significance and prognosis.

The studies of clinicians and physiologists of recent years have advanced our knowledge greatly in this field, and irregularities of types which were formerly mysteries are now clearly demonstrable.

In the analysis of disordered mechanism of the heart's action three mechanical methods are open to use:

First. Arterial Pulse Curves—the radial or brachial arteries being the ones usually chosen. These curves, while simply carried out, give fairly accurate indications of the character of any irregularity which may be present, and need only confirmation by one of the more elaborate methods.

Second. Venous Curves—taken by means of

the polygraph. These give us, in addition to the information obtained from arterial curves, the valuable, and often essential, information regarding the action of the auricle.

Third. Electrocardiographic Curves—which provide by far the most accurate information, and in some instances are indispensable to the making of an absolute diagnosis.

The normal starting place of the heart's contraction lies in the small node of tissue situated at the mouth of the superior vena cava,—the sino-auricular node. This is normally the most readily excited portion of the auricular musculature. It must be remembered, however, that if any other point becomes for some reason more excitable than the sino-auricular node, then the contraction will have its origin in this abnormal focus. Defects may thus arise in stimulus production, or equally in one of the other heart muscle functions, and consequent disturbances in rate and rhythm may result which may lead to the onset of a degree of heart failure.

Of disturbances arising at the site of stimulus production, the most frequent is the sinus arrythmia, or respiratory arrythmia. In this irregularity the whole heart is affected. Aside from the irregularity, the venous and electrocardiographic curves are normal. The irregularity usually presents a cycle which is coincident with the phases of respiration, the heart's rate increasing with inspiration and decreasing on expiration. The condition is probably of vagus origin. The diagnosis may be made on the character of the irregularity, usually altering with respiration, and of which the patient is quite unconscious. An important point is that the patient's condition gives no evidence of cardiac failure.

Probably the simplest form of irregularity is that present with the so-termed intermittent pulse. In this group, the most frequent of occurrence is the premature ventricular contraction or extra-systole. When from any cause a ventricle is stimulated during its period of diastole it contracts, and if this stimulation comes before the allotted time of auricular stimulation a premature ventricular beat occurs. This contraction, arising from abnormal source below the level of the auricle, does not interfere with the dominant heart rhythm as initiated in the auricle; the auricle maintains its normal regular rhythm. Usually the normally placed auricular contraction falls almost simultaneously with the ventricular extra beat, and as an independent wave is lost to view in the mechanical records. The auricular contraction falling with the premature ventricular contraction, occurs in the so-called refractory period of the ventricle, and consequently produces no ventricular response. Following the early ventricular contraction there is a pause, and provided the abnormal stimulus is not repeated, the ventricle waits for the next auricular contraction, and contracts in response to the normal stimulus. This pause following the extra beat is characteristic of the condition, and is of such length, that together with the shorter than normal pause immediately preceding it, is just equal to two cycles of the normal rhythm. Clinically, the premature ventricular contraction may or may not be perceptible at the wrist, but it can always be heard on auscultation. Ventricular premature beats are of frequent occurrence, probably in the majority of instances the subject is not aware of them; when he is, he is conscious of one of two things, either of the long pause in the heart's action, when he may have a feeling of faintness, or he may be conscious of the more forceful contraction coming after the pause.

A second variety of premature beats arising within the ventricle belong to the class known as interpolated extra-systoles. Here the premature beat falls mid-way between two normally placed ventricular contractions. They differ from the type just described, chiefly in there being no compensatory pause following the early ventricular contraction. When the heart's rate is slow, it is possible for a ventricular stimulus arising in an abnormal focus to occur early enough to permit of the succeeding auricular contraction coming at a sufficiently late interval to give rise to a ventricular response correctly timed. Clinically these interpolated extra systoles will be evidenced only on auscultation as a heart beat placed mid-way, or nearly so, between two normally occurring heart beats. There is no evidence of the premature beat in the radial pulse curves which present an unbroken line.

Arterial records of ventricular extra-systoles will vary in accordance with the force of the extra beat and the volume of the ventricular output. The premature beat may occur so early in diastole that (as a result of a very short preceding period of rest) the ventricular contraction will be too weak, and the volume of contained blood within the ventricle too small, to raise the aortic valves. Under these circumstances the contraction is, of course, not shown in the arterial tracing, and we see only an intermission in l ngth equal to two normal cycles. Extra-systoles fall-

ing later in diastole may be evident in the arterial tracing as small beats followed by a compensatory pause. The first beat recorded following the abnormal one will usually be larger than the normal, the reasons for this being, first, that the heart has had a longer period of rest and is consequently better equipped for a contraction; and, second, that the volume of blood contained within the ventricle is slightly in excess of the normal.

Venous curves show a continuous and regular sequence of A waves significant of auricular contractions, the ventricular irregularity being also clearly in evidence.

Electrocardiograms give most accurately the sequence of events occurring within the heart chambers; they also give us information regarding the area from which the extra-systole arises.

On auscultation ventricular extra-systoles are always accompanied by at least the first sound coincident with the closure of the mitral valves; but in those cases in which the extra-systole occurs early in diastole, and in the presence of interpolated extra-systoles, the second sound may be absent or much altered.

Extra-systoles may also have their origin at some point within the auricle. When a premature contraction takes place in the auricle it is always followed by a contraction of the ventricle. Clinically extra-stoles arising within the auricle may or may not be conspicuous, the pause following them is irregular, and almost never compensatory. Frequently accurate measurement is necessary to demonstrate their presence.

Arterial curves show the disturbance of the rhythm.

In venous curves a definite auricular wave is seen preceding a premature C wave.

Electrocardiographically the occurrence of auricular extra-systoles is readily demonstrated by the presence of an auricular contraction of abnormal type preceding a premature ventricular wave. Also by the electrocardiographic method the abnormal form of the wave indicating auricular contraction gives us additional information regarding the point in the auricle from which the abnormal wave originates.

Mention should be made of the fact that premature beats may occur at the junctional tissues between auricle and ventricle, but they are of rare occurrence, and aside from electrocardiographic means are difficult of diagnosis.

In the past it has frequently been held that extra-systoles are evidence of an over excitability of the cardiac muscle. To-day the best authorities agree that the presence of these extra beats arising spontaneously give no evidence of any significant cardiac disturbance.

Another type of intermission occurs when there is some obstruction in the conducting mechanism between auricle and ventricle, with the result that there is a blocked ventricular contraction. This brings us to the consideration of Heart Block. Normally, the contraction of the ventricle following the auricular contraction is dependent upon the integrity and efficiency of the auriculo-ventricular node. Further, it should be noted that the normal ventricular response is dependent not only on an intact A. V. node, but also on the properly conducting bundle and its divisions beyond the node, and where an abnormal condition occurs in any part of this system, we will find either blocked ventricular contractions, or some degree of abnormal ventricular response depending upon the site and extent of the pathological process.

Heart block in man arises in one of three ways:

1. Injury to the auriculo-ventricular node, or to the main stems of the conducting system below the node.

2. Through influence of the vagus. It is to be noted that this type is abolished by atropine; also vagal blocks are usually of short duration.

3. Through the action of poisons. In the therapeutic field this is chiefly seen with overdoses of digitalis.

Various degrees of block are recognized. The first to appear is usually the incomplete block. In this stage occasional auricular contractions meet with no ventricular response. Before the actual appearance of dropped beats there is, however, a stage which should be noted, in which the defect is slight. Here we may have only a delay in the conduction time from auricle to ventricle. The ventricle may respond to all auricle contractions, but only after an abnormal period of time. Then with the onset of a higher grade of block there comes the occasional failure of the ventricle to respond to an auricular contraction, and we have a dropped beat. This may be recognized clinically by a silent period. This pause is not as a rule equal to two normal cycles, because the condition is usually accompanied by a slight variation of response on the part of the ventricle both in the cycles preceding and following the dropped beat, this being such that the silent period is less than two normal cycles.

With a progressive lesion the occurrence of Propped beats becomes more frequent, and a regular sequence of failures in ventricular con-

traction appears. It is then that a fixed ratio between auricular and ventricular contractions becomes established and we have a resulting 2 : 1, or more rarely a 3 : 1 or 4 : 1 heart block; *i.e.*, there is response on the part of the ventricle to only every second, third or fourth auricular contraction.

A still more advanced grade of block is initiated when the ventricle fails to respond to any of the auricular impulses, and there is complete dissociation between the two portions of the heart. Here the stimulus for the auricular contraction arises in the normal pace maker, and the auricle responds normally to this stimulus and contracts at its normal rate of 76, or thereabouts, to the minute. The stimulus for the ventricle, however, arises from a point within the ventricle itself. The rate of the ventricle under these circumstances is slow, approximately 30 to the minute, and the rhythm is regular. Regarding diagnosis: Of primary importance on auscultation, is the reduced ventricular rate. On careful auscultation the auricular sounds are frequently audible during the silent periods of the ventricle. Also in complete block when an auricular systole falls with a ventricular systole there may be an intensification of the sound. If there should be an accompanying mitral stenosis, a murmur may be audible on the occurrence of those auricular systoles which fall during the silent period of the ventricle. On inspection, a pulsation in the vessels of the neck corresponding to auricular systole is often visible.

Mechanically, the presence of heart block may be demonstrated by any method displaying auricular and ventricular activity; most satisfactory by the electrocardiograph.

Another source of dropped beats is found in sino-auricular block. In this, the defect occurs at the normal source of stimulus production, where apparently a failure in the initiation of the impulse occurs. This type differs from the auriculo-ventricular block in that the missed beats include both the auricle and ventricle. The condition is not of major importance. For absolute diagnosis one of the methods displaying both auricular and ventricular action is necessary.

In the types of irregularity thus far considered, there has been with all a dominant controlled rhythm. This latter may be demonstrated, when throughout a heart tracing, there are runs of successive regularly placed beats. This is of importance in differentiating irregularities of the ventricle from one such as fibrillation of the auricles.

In fibrillation of the auricles we pass to the completely irregular pulse, in which the intervals between the beats are of varying lengths and where there are no phases of irregularity falling into any system. The clinical condition is characterized by a completely irregular ventricular action, and by a complete absence of any normal auricular contraction. It is the condition which is the most frequent cause of persistent irregularities found in the heart's action. It is frequently associated with mitral stenosis.

The pulse rate may be slow or fast, the usual rate being about 120. The force of successive beats varies in a marked degree. It should be noted, that in the presence of auricular fibrillation the radial pulse is a poor index of the actual heart rate, as it frequently happens that many of the ventricular contractions are abortive, and fail to produce a pulsation in the radial artery; this gives the so-called pulse deficit. The only reliable method of ascertaining the heart's rate is by auscultation over the precordium.

In arterial curves the condition is recognizable, first, by the absolute irregularity of the spacing, it seldom being found that any two successive beats show an equal pause between them. Second, there is a lack of uniformity in the force of successive beats.

In venous or electrocardiogaphic curves, the most striking feature is the complete absence of any evidence of auricular activity.

In the course of treatment with digitalis, the typically irregular ventricle of fibrillation may become almost, or occasionally quite regular. This does not mean cessation of the fibrillation, but it does demonstrate the production of a high degree of heart block.

Fibrillation may be accompanied by extra-systoles of ventricular origin. The presence of ventricular extra-systoles, alternating with ventricular contractions of the normal type, is a characteristic, and not infrequent form of irregularity seen accompanying over-dosage with digitalis.

There are two important abnormal rhythms which, while not so frequently seen, are nevertheless worthy of note. The first of these is paroxysmal tachycardia. Sudden increases in the heart rate, having their origin in the normal pacemaker, may be physiological, *e.g.*, in nervous individuals, under stimulus of some excitement, these attacks may be accompanied by the sensation of palpitation. Again, disturbances of a like character are found in certain pathological conditions, as exophthalmic goitre.

In addition to these forms, there remain a large group of tachycardias for which there is no etiological basis, where, for varying periods the normal heart rhythm disappears, and the heart responds to stimuli arising at a rapid rate from some new source. The onset is abrupt, as also is the termination of the attacks. The paroxysms may arise in the auricle, in the region of the auriculo-ventricular node, or in the ventricle. Their origin may frequently be determined by venous curves, or more precisely electrocardiographically.

Paroxysmal tachycardia arising in the ventricle is much less frequent than tachycardia of auricular origin. The attacks are usually of short duration, while the auricular variety may continue for hours or even days. The ventricular type is more difficult to diagnose than those of auricular origin. Electrocardiograms are practically essential in establishing the site from which the new rhythm arises.

A condition closely allied to the abnormality just described as auricular tachycardia, is the one known as auricular flutter. Lewis considers the possibility of the difference between the two being one of degree only. He classifies auricular flutter as those cases of abnormal rhythm which present an auricular rate surpassing 200 per minute, and in occasional instances ataining a rate of 350 per minute.

The auricular rate in flutter is extremely regular. With regard to the ventricle, it is in exceptional instances and then only for short periods of time, that the ventricle assumes a rate equal to that of the auricle. The usual condition is that of a two to one heart block, or even greater, a four to one not being uncommon. As a rule the greater the rate of the auricle the slower is the ventricular rate. It should be noted that the action of the ventricle may or may not be regular. The clinical diagnosis must be made on the usually extremely rapid heart rate. Venous and electrocardiographic curves show a regular sequence of auricular waves exceeding 200 per minute and a ventricular rate and rhythm which may be variable.

Read before Section of Medicine, Academy of Medicine, Toronto, November 9th, 1920.

EPIDERMOPHYTON INFECTION

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Toronto

EPIDERMOPHYTON infection gives rise to a special type of ringworm. It attacks moist opposing surfaces, especially the inguinal region. It may be limited to the inner surface of the thighs and the folds of the groin or it may affect the genital organs. It is often seen in the axillæ, in the umbilical fold or beneath the breasts in stout women. It is not uncommon about the feet, especially between the toes and on the soles.

Since the war, amputation cases have been seen in which the ringworm spreads about the margin of the amputation sock following the primary infection of the inguinal region.

Certain clinical characteristics serve to distinguish it from ordinary ringworm of the body. It begins as slightly raised, rounded papules which, owing to the moisture of the part, instead of being scaly, are liable to present a raw sodden surface. The papules spread peripherally, the border becoming raised and well defined. Occasionally the patches clear up in the centre forming circinate lesions.

On account of the warmth and moisture of the region involved, the fungus grows rapidly and gives rise to considerable irritation. This is again aggravated by the friction of the clothes. The lesions, due to scratching, may become secondarily infected with cocci. The affection has a tendency to improve in the cold season, but it usually reappears with the return of the warm weather.

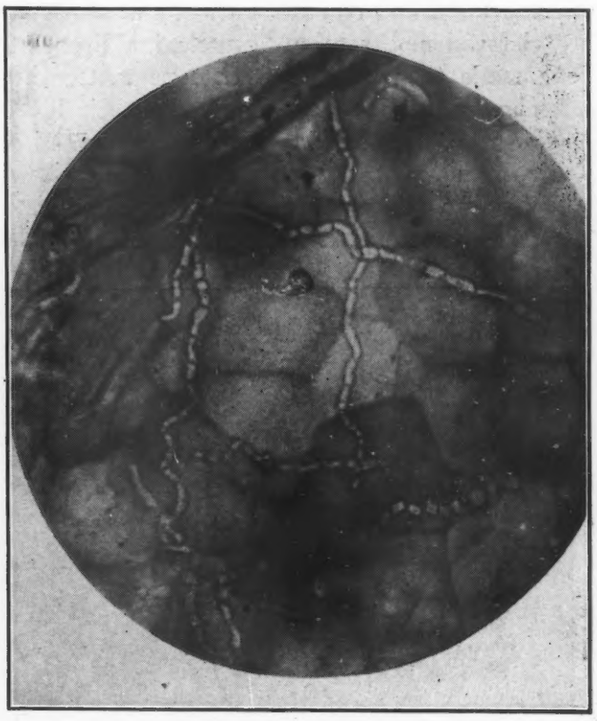
The manner in which it is contracted is uncertain. It may be transmitted directly by contact,

from wearing infected clothes, or the use of water-closet seats, etc.

The special characteristics, when affecting the toes are congestion, fissuring and white macerated sodden appearance of the skin, especially between the toes. On the soles, as a rule, it presents irregular, scaly, sharply defined patches with little hyperæmia and occasionally vesicles can be noticed.

ing across the whole field. It resembles a chain of white, oval beads.

The treatment to be followed depends upon the clinical features of the case. In one with marked inflammatory reaction, a mild, soothing, antiseptic ointment is indicated; occasionally, during the day, a lotion such as lotio calaminæ with a little boracic acid, gives great relief, and the ointment can be applied at night, after the inflammation



In a large percentage of cases, if not previously treated, the fungus can be demonstrated. Probably the simplest method is to take a scraping of the border, place the scales on a glass slide, add a few drops of potassium hydrate (10 per cent.) and cover with a cover slip. Allow the solution to act for a few minutes and examine under the high power lens. Branched mycelial threads are seen running between the epithelial cells and extend-

has subsided, or in a case with very little inflammation, an ointment containing acid salicylic, 1 per cent.; acid benzoic, 1½ per cent. to the ounce of vaseline is most useful. To eradicate the condition, the acid salicylic and the acid benzoic have to be gradually increased in strength. Other ointments containing mercury or iodine are often efficacious. The underwear should be sterilized frequently.

THE USE OF LIVING SUTURES IN OPERATIVE SURGERY*

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Toronto

SOME years ago, during the course of an experimental and clinical study of the conversion of the tendons of paralyzed muscles into ligaments, we made the observation that no matter how freely the tendons were deprived of their blood-supply, they continued to live, and when examined months and years afterwards, presented the same glistening white appearance and the same histological characteristics as normal tendon.† This observation suggested the possibility of using free transplants of tendon or fascia in operations in which it is intended to fasten together structures which naturally tend to separate. A review of the literature at once showed that the autogenous transplantation of tendon and fascia had frequently been employed clinically and that it had also been carefully studied in the laboratory. We were particularly struck with the experimental and clinical work reported by Dean Lewis of Chicago. Lewis showed conclusively that the tendinous fasciæ could be transplanted to another position in the same animal with the reasonable certainty that they would continue to live and retain their normal gross and histological characteristics. He applied the principle thus demonstrated by experiment to the filling in of gaps in tendons produced by lacerated wounds and burns, and to the making of fascial sheaths to protect the point of suture of severed nerves from the ingrowth of ordinary scar. With this knowledge as a starting point we commenced a series of experiments on animals and a study of the clinical material which came under our observation, which has extended over a period of eight years, and we feel that sufficient time has now elapsed to justify a preliminary report of our studies.

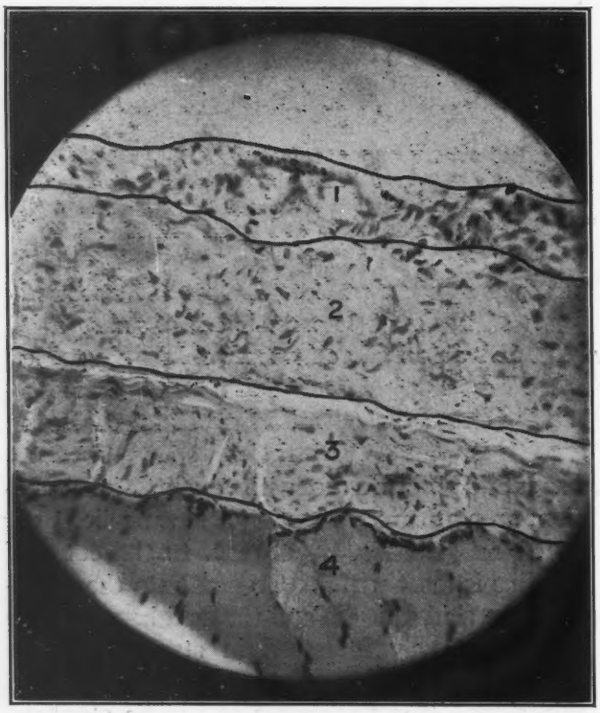

Fig. 1. Normal fascia and aponeurosis from rabbit's back, showing arrangement of fibres and cells. (High power.) 1. Vascular areolar tissue on surface. 2. Deep fascia of back. 3. Aponeurosis. 4. Muscle.

If a strip of fascia is examined under the microscope, it will be seen to consist of a mass of very thick parallel fibres which run a straight or slightly wavy course (Fig. 1). Between these fibres are scattered a small number of connective tissue corpuscles (tendon-cells). The fibres are gathered into bundles which are separated by a small amount of areolar tissue. In this areolar tissue run a very few blood-vessels and many lymphatics which pass into the fascia from a layer of similar tissue on the surfaces. The nutrition of the fibres and cells is evidently maintained by the free percolation of lymph through the tissue spaces. The aponeuroses and the tendons are practically the same as fascia except that the former are adherent to muscle on one side and the latter are in the form of stout cords instead of flat sheets. In tendon the trabeculæ of areolar tissue are more

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* The research involved in this paper has been carried out in the laboratories of the University of Toronto, with the assistance of the funds at the disposal of the Medical Research Committee.

† "Tendon Fixation," etc. *Annals of Surgery*, March, 1913; *Journal American Orthopedic Association*, January, 1916.

pronounced and carry somewhat larger blood vessels. The parallel arrangement of heavy fibres in fascia and tendon gives these tissues great strength in one direction, that is, in the direction in which they are normally subjected to strain. In this respect they differ from scar-tissue, in which the fibres, although of considerable size, are arranged irregularly.

Our first experiments were practically a repetition of those described by Lewis. The animals used were rabbits and the operations consisted of the excision of patches of fascia which were immediately sewn back in place with black silk thread. The specimens were recovered at intervals ranging from a few days to many weeks.

During the first few weeks the specimens showed the ordinary phenomena of inflammation (Fig. 2). At first the blood-vessels in the tissues surrounding the transplants were much engorged and the whole area was covered with a plastic exudate. Very soon a thin transparent film developed over the transplant, consisting of capillary blood-vessels and fibroblasts. This film rapidly increased in thickness, and, by the end of the third week, consisted of a mass of spindle-shaped cells and fibres. The blood-vessels in this film increased in size at a corresponding rate until they could be seen with the naked eye, running across the line of suture and on the surface of the patch of fascia. During this time the transplant remained alive and showed on microscopic examination very little change beyond a moderate œdema. Its outline remained distinct, without any evidence of invasion by new blood-vessels or connective tissue, and without any leucocytic infiltration. The fibres and cells continued to stain well.

After the third week the inflammatory phenomena gradually subsided. The hyperæmia and œdema slowly disappeared and the film on the surfaces of the transplant became as thin and transparent as the layer of areolar tissue on the surface of normal fascia. In specimens recovered as late as a year after the operation there was nothing to indicate that the cells or fibres had been changed in any way or that their physiological value had been influenced by the transplantation (Fig. 3).

In a second series of experiments similar to those described we made a study of the transplantation of the aponeuroses of muscle. These aponeurotic transplants behaved exactly as did the pieces of deep fascia. The cells and fibres continued to live, and underwent no change further than that produced by the primary inflammatory œdema. No absorbtion, invasion or infiltration occured and there was no evidence of proliferation on the part of the cells. After the fourth week the transplanted tissue could not be distinguished from normal aponeurosis.

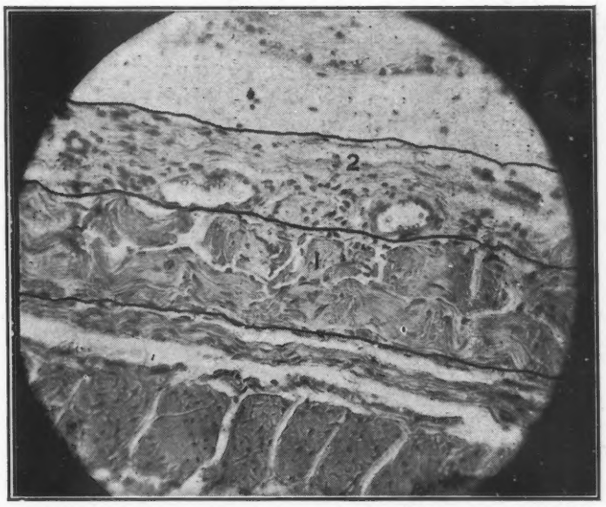

Fig. 2. Fascial transplant after three weeks. (High power.) 1. Fascial transplant. 2. Thick film of very vascular areolar tissue on surface.

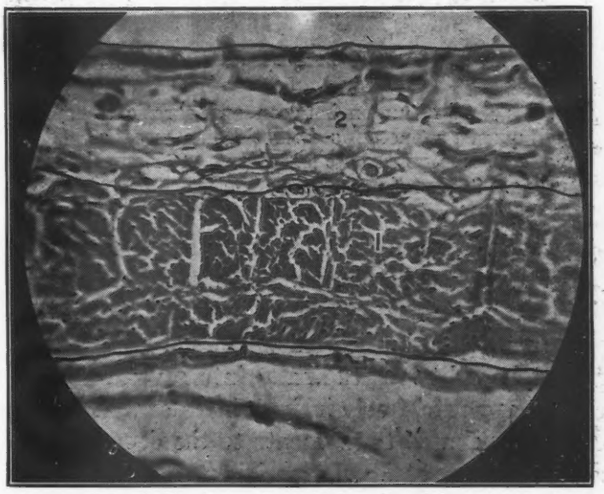

Fig. 3. Fascial Transplant after thirteen months. (High power.) 1. Fascial transplant. 2. Areolar tissue on surface with normal blood supply.

In a third series of experiments our attention was directed to the transplantation of tendon. Sections of the rabbit's tendo Achillis, or one of its component parts, were cut entirely free from the circulation and then sutured back in place with black silk thread. The specimens were recovered at varying intervals up to thirteen months. The results of these experiments showed that tendon behaves exactly as do fascia and aponeurosis. If the transplanted tendon is thick,

Fig. 4. Line of union between aponeurotic transplant and normal aponeurosis after thirteen months. (High power.) 1. Aponeurotic transplant. 2. Normal aponeurosis. 3. New tissue uniting the two.

however, the central portions undergo degeneration owing to the absence of an adequate supply of lymph. This observation indicates that if it ia necessary to use thick transplants of tendon they must be split longitudinally into several strands or, at any rate, freely incised, in order that lymph may be allowed to permeate to the deeper parts.

In all three series of experiments an observation was made which is of the utmost clinical importance. It has been pointed out that neither in fascia, aponeurosis nor tendon is there any evidence of proliferation of the essential cells of the tissue. When healing occurs, therefore, the connective tissue which forms at the point of union arises from cells which are not tendon-cells, and which cannot be expected to produce true tendinous tissue. In point of fact, they produce an ordinary scar (Fig. 4). Scar-tissue differs from fascia and tendon in that, although it is composed of quite similar white fibres, these fibres are very irregularly and loosely arranged and when subjected to continuous strain show a constant tendency to stretch. In many of our experiments this defect in the "patch transplant" method was clearly demonstrated. In these it was found that, whereas at the time of the operation the patch was accurately stitched in place with silk or catgut, when the specimen was recovered, weeks or months afterwards, the sutures had cut out or absorbed and the cut edges of the fascia or aponeurosis had separated widely owing to stretching of the scar or areolar tissue which constituted the line of union (Fig 5). This defect was even more noticeable in the operations on tendons. Herein lies the explanation, therefore, of the failure of many of the attempts which have been made to cure large hernias by the use of patch transplants and to bridge gaps in damaged tendons by end-to-end suture of transplants of tendon or fascia.

As a result of these observations it became evident that before the transplantation of tendinous tissues could become of real clinical value, some method must be discovered of securing a firm union of the transplant to the surrounding structures. With this object in view we did a series of experiments in which a piece of fascia a quarter of an inch wide and two inches long was removed from the animal's back and then placed

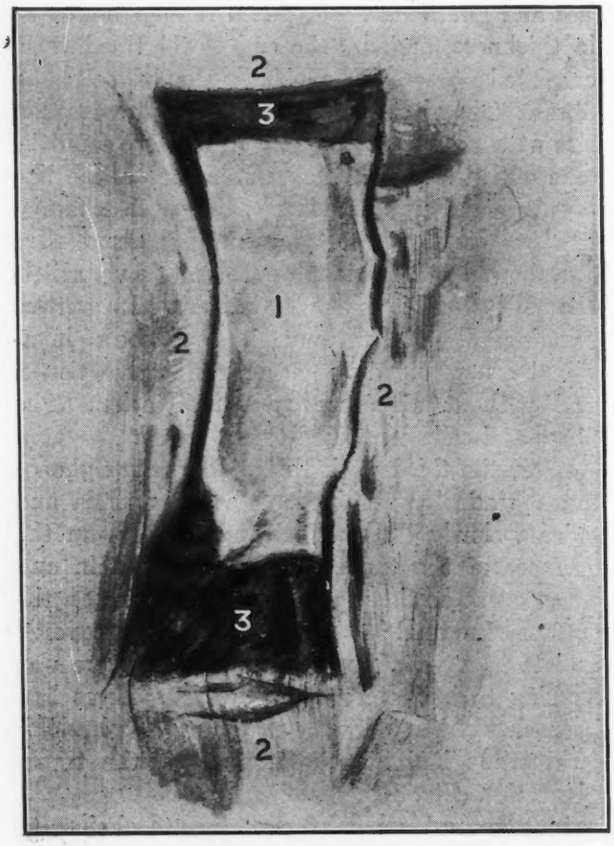

Fig. 5. Drawing of "patch" transplant of aponeurosis after thirteen months. 1. Aponeurotic transplant. 2. Edge of normal aponeurosis. 3. Thin film of new tissue uniting the two. At the operation, the transplant was accurately sutured all around its edge to the normal aponeurosis. Union has taken place by the formation of areolar tissue, which has stretched considerably.

transversely across the middle of the gap and woven two or three times into its edges (Fig. 6). The transplant was fastened in place by catgut sutures inserted at the points where it passed through the deep fascia. When the operation was completed the edges of the fascia were still a quarter of an inch apart and held in this position by the transplant which crossed the gap. These experiments were also repeated with the substitution of free transplants of aponeurosis and tendon for the fascia. This investigation showed that the solidity of the union of the transplanted fascia to the edges of the gap depended on the extent to which the former was woven into the latter. If the transplant passed only once or twice through the fascial margins, it usually failed to prevent the edges of the gap from stretching apart. If it were well woven into the edges, however, no separation occurred. The strength of the union also depended on the care with which the portion of the fascia used in the weaving was cleared of areolar tissue. Actual scraping and scarification of this part of the transplant produced the best results. Examination of the points of contact of the transplant and the surrounding fascia showed that the union occurred by means of new-formed connective tissue which ranged from the loose texture of areolar tissue to the firmness of ordinary scar. It is evident, therefore, that in order that the union may be strong enough to stand the normal physiological strain the transplant must be in actual contact with its bed over a considerable distance. This observation has proven of the greatest clinical importance and has resulted in the development of a special operative technique to which we attributed the success of most of our operations.

In many operations, however, such as the repairing of gaps in the fascia of the rabbit's back, the weaving of the transplant into the edges of the gap and anchoring it with catgut sutures is too laborious and uncertain a procedure to make it applicable to ordinary operative surgery. The search for a method of overcoming this difficulty finally led to the idea of using long strips of fascia and threading them on large-eyed needles, thus converting the transplants into living sutures. The idea was immediately tested experimentally and has proven to be the most valuable result of our research. In these experiments a strip of fascia, a quarter of an inch wide and six or seven inches long, was removed from the animal's back and threaded into a needle (Fig. 7). It was found necessary to tie the fascia into the needle as it is

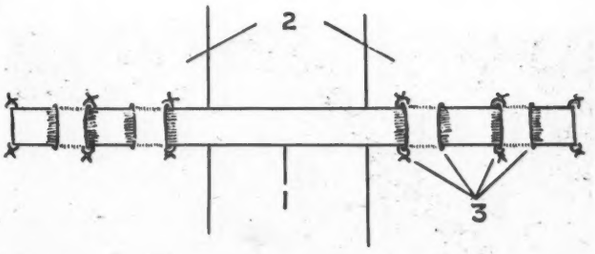

Fig. 6. Diagram showing method of fixation of "strip" transplant by weaving through slits in the fascia on either side of the gap. 1. "Strip" transplant. 2. Edges of gap in fascia. 3. Slits through which strip is woven and fixed by sutures.

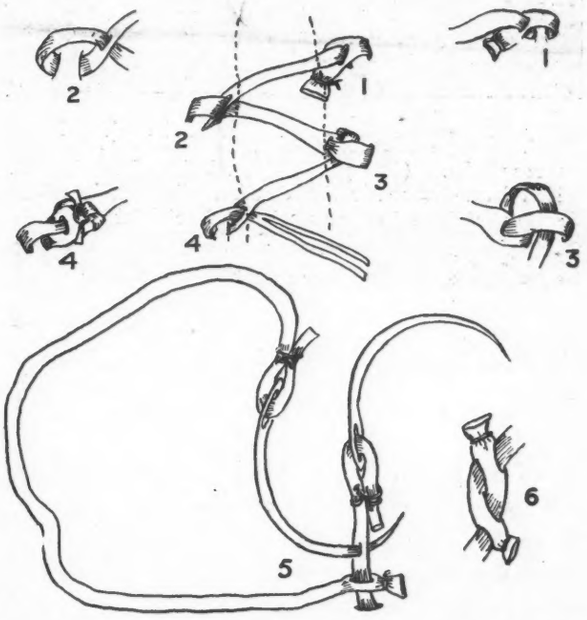

Fig. 7. Diagram showing method of inserting fascial suture. 1. Anchoring suture at commencement by looping it through itself. 2. Fixation of suture at each loop by passing it through itself. 3. Fixation by passing suture through itself and tieing in knot. 4. Ending of suture by passing through itself, splitting, and tieing ends in knot. 5. Method of joining new suture to one that has been inserted. 6. Join completed.

so slippery that it will otherwise constantly slide out of the eye. A catgut ligature was also tied about the terminal end of the fascial suture to prevent splitting. The needle was now passed through one of the edges of the fascial gap and then through the terminal end of the living suture and the suture drawn taut. The needle was again passed through the edge of the fascia and also through the fascial suture to make doubly sure that the anchor would hold. The needle was then carried across the gap in the fascia and passed through the edge of the opposite side. When the suture had been drawn taut the needle was either passed through the suture and again through the

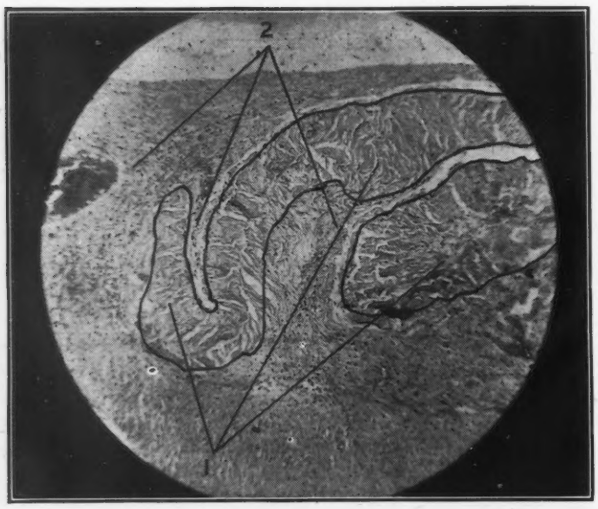

Fig. 8. Cross-section of portion of fascial suture after three weeks. (Low power.) 1. Folds of fascia. 2. New-formed vascular tissue surrounding whole suture and extending into spaces between fascial folds.

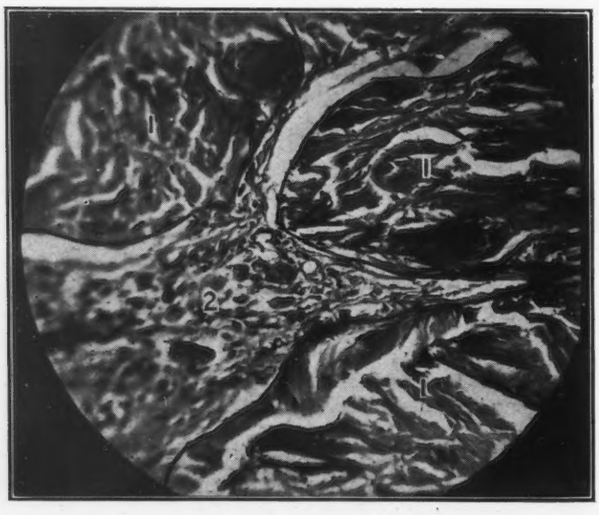

Fig. 9. Same as fig. 8., but under high power. 1. Folds of fascia. 2. New tissue between folds. The cells of the fascia are staining well, the outline of each fold is distinct, and there is no invasion of the fascia itself by the new tissue.

edge of the gap, or was passed through the edge of the gap and then looped so as to anchor the suture by a knot in itself. These details were found important as the fascial suture shows a marked tendency to slide. The knot proved the most effective means of anchoring it. In this way the suture was passed backward and forward obliquely across the gap, leaving its edges a quarter of an inch apart, until nearly all the strip of fascia had been used up. The needle was then passed several times through the edge of the gap, transfixing the suture each time, after which it was removed and the terminal inch of the fascia split longitudinally. The tails thus formed were used to tie a triple knot which was finally securely fastened by transfixion with catgut. The edges of the gap were thus held together at a distance of a quarter of an inch from each other by what might be called a living filigree. The suture was practically completely exposed to view and every opportunity was afforded for study of the changes which might occur during the succeeding periods of time.

The specimens were recovered at intervals of one week up to a little over a year. They show that the fascial sutures behave in practically the same way as the transplants in the first series of experiments. There is the same early inflammatory dilatation of the neighbouring blood-vessels and the formation of a film of exudate over the whole operative field. Soon minute blood-vessels can be seen spreading through this film on the surface of the suture. As the suture presents a folded appearance on cross-section, the film of exudate, which later becomes areolar tissue, extends into the spaces between the folds of fascia, bringing blood-vessels intocontact with all its surfaces (Figs. 8 and 9). During the first three weeks the suture is appreciably swollen, owing to œdema, but during the succeeding weeks this œdema disappears and the new-formed connective tissue shrinks into a delicate layer of vascular membrane. By the end of the sixth week the transplant has become a narrow rounded cord, closely resembling normal tendon (Figs. 10, 11 and 12). On cross-section its original folded appearance has disappeared and it is seen to consist of bundles of strong white fibres and tendon-cells separated by trabeculæ of areolar tissue which carry the blood-vessels from the surfaces. In all the specimens examined the fibres and cells have remained unchanged and, beyond the transient œdema of the first three weeks, show no evidence of inflammatory reaction. The specimens recovered at the end of a year are practically the same as those recovered at the end of six weeks (Fig. 13).

These experiments conclusively demonstrated the clinical value of the principle of the use of living sutures. The edges of the gap in the fascia were solidly held together as at the time of the operation. The suture had healed to the edges at all the points of transfixion and the loop and knots had become reduced to small nodules of fibrous tissue. At no point had the suture cut

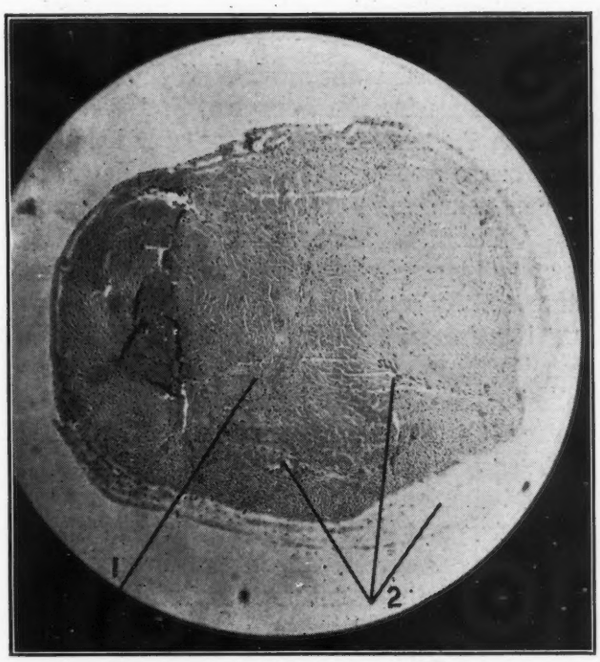

Fig. 10. Cross-section of fascial suture after six weeks. (Low power.) The suture is now a rounded cord. The separate folds can no longer be distinguished, and the new tissue between them is represented merely by narrow trabeculae of connective tissue. 1. Rounded cord of fascia. 2. Vascular areolan tissue.

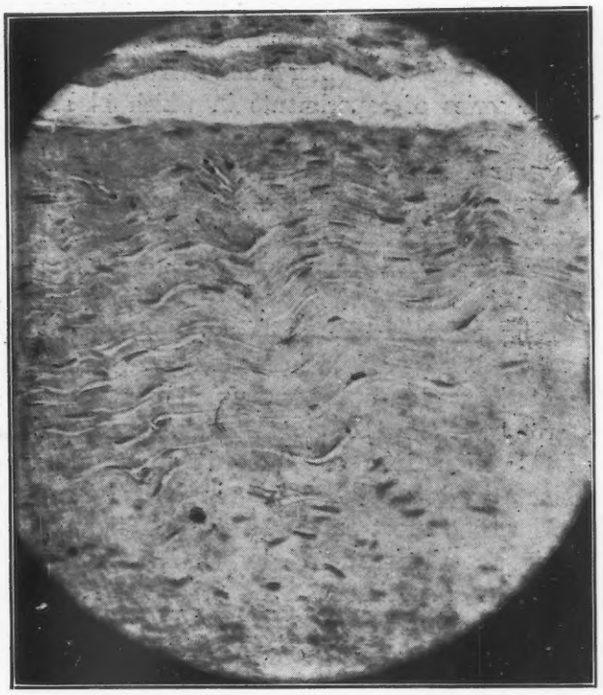

Fig. 12. Longitudinal section of fascial suture after six weeks, showing the persistance of the normal parallel arrangement of fibres. (High power.)

Fig. 11. Same as fig. 10, but under high power. 1. Connective tissue between folds of fascia. 2. Fascia, which is obviously living, and resembles normal fascia in every way.

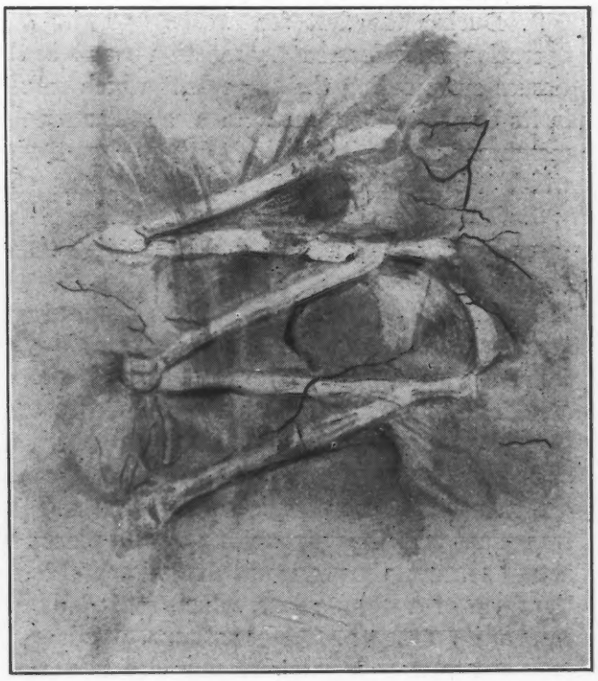

Fig. 13. Fascial suture at end of thirteen weeks, showing method of insertion. The suture is now a rounded glistening cord, resembling tendon in gross appearance.

out or become loosened, nor was there any evidence of stretching or contracture of the suture itself. This latter observation was amply proven in a series of experiments in which black silk markers were tied on the suture at accurately measured intervals. When the specimens were recovered these markers were always at practically the same distance from one another. Further, in no case had rupture of the suture occurred. Even in rabbits the strips of fascia are very strong, stronger than ordinary number two catgut, and strips of human fascia lata, which is the material we have used in surgical operations, are stronger than the stoutest kangaroo tendon. Destruction of the normal blood-supply and transplantation to another position in the body appears to have no effect on the strength of the suture. This was demonstrated by testing the tensile strength of specimens in a special machine after recovery at various intervals.

The results of this experimental study of the transplantation of the various fibrous tissues may be summarized as follows:

1. When a piece of fascia, aponeurosis or tendon is cut free from its circulation, and transplanted into such a position in the same animal that it can receive an adequate supply of lymph, it will continue to live, and, for all practical purposes, will continue to live unchanged.

2. During the first few weeks following the operation, an inflammatory reaction occurs in the tissues surrounding the transplant which results in its complete investment in a vascular areolar membrane and in its healing to those tissues with which it comes into immediate contact.

3. Such transplants heal to surrounding structures by means of new-formed connective tissue and it is upon the strength of this connective tissue that the firmness of the fixation of the transplants depends. If the operation is performed without the complete removal of the areolar tissue which normally ensheathes the transplant the union will have merely the strength of areolar tissue. If, on the other hand, the areolar membranes are completely removed and the transplant and the surrounding tissues placed in actual contact, the nature of the union will be in the form of a fibrous scar, which materially increases its strength. As scar-tissue, however, is very apt to stretch under even moderate degrees of strain, it becomes essential to place the transplant in contact with the surrounding tissues over a considerable distance in order that the amount of scar-tissue in the line of union may be sufficiently strong to withstand any degree of physiological strain.

4. In many cases the mechanical difficulties in the way of placing the transplant in actual contact with the surrounding tissues over long distances are so great that the method just described becomes valueless in ordinary operative surgery. These difficulties, however, can be completely overcome by employing the fascia or tendon as a suture and by weaving it securely into the surrounding tissues. In this way the necessity for removing the areolar membranes from the surfaces is eliminated and one no longer depends upon the healing of the transplant to the surrounding tissues for the success of the operation. The strength of the bond of union will now depend on the strength of the transplant itself and of the structures into which it is woven. If the surgeon is careful to choose for his living suture a material which is known to have the necessary strength to withstand the anticipated strain, and if the suture is securely anchored into tissues which can also tolerate this strain, the permanent union of these tissues can be confidently expected.

The principles developed from this research are of great clinical importance. For a number of years it has been known that the fibrous tissues could be transplanted with the expectation that they would live, and many operations have been reported in which the principle has been employed. The method has never become popular, however, owing to the frequency with which the operations have failed as the result of stretching of the scar-tissue which forms the bond of union. A striking example of such failures is seen in the attempts which have been made to repair large ventral hernias with patches of fascia lata. These patches were either cut to fit the opening in the abdominal wall or made to overlap its edges slightly, and fastened in place with catgut or linen sutures. The explanation of the failure of these operations to cure the hernias is simple when one considers the weak character of the healing at the edges of the transplant. To this insecure union, in fact, can be attributed most of the failures which have attended so many of the operations in which transplanted fibrous tissues has been used.

It is not our intention to describe in this paper the details of the variety of operations in which the principles evolved from this research have been employed. These will form the basis of future publications. We shall be content at present to indicate the various fields in which the method has been or may be used and to give a few

examples which demonstrate its clinical value.

One of the most suitable fields for its employment is in the repair of injured ligaments or in the making of new ligaments for the prevention of paralytic deformities. An excellent example of the former was provided some months ago by a man of forty years of age who came to us with a history that a year previously he had fallen down stairs, striking his left knee against a radiator. The initial signs of trauma were very severe and the disability since that time such that he has been unable to carry on his trade as a bricklayer. This disability consisted of lack of power to extend the knee, with the resulting insecurity in walking and total inability to climb. Examination showed a complete rupture of the ligamentum patellæ. In this case we performed the following operation: The patella, the remains of the tendon and the anterior surface of the upper end of the tibia were exposed by an "S"-shaped incision. Two quarter inch holes were drilled obliquely through the patella, the first extending from the outer edge of the quadriceps tendon to the inner side of the ligamentum patellæ and the second from the inner edge of the quadriceps tendon to the outer side of the patellar ligament. The two holes thus crossed within the patella. A larger hole was then drilled perpendicularly into the tibia at the junction of the patellar tendon with the tubercle and two other holes which commenced an inch lower down on the internal and external surfaces made to meet the first hole in the depths of the bone. The tendo Achillis of the same side was then exposed and a segment about seven inches long and half its thickness removed. The whole of the plantaris tendon was also excised. The segment of the tendo Achillis was split longitudinally into two equal portions and thoroughly scraped on its superficial surface until all areolar tissue had been removed, and then carefully scarified. The remains of the ruptured ligamentum patellæ were split longitudinally, so as to expose the synovial membrane of the joint. The segments of tendo Achillis were then drawn taut and anchored by catgut sutures passed through their exposed extremities and the neighbouring periosteum. Between the lower end of the patella and the tubercle of the tibia the new ligaments lay on the synovial membrane and between the remains of the ruptured ligamentum patellæ. The plantaris tendon was now threaded on a large-eyed needle and anchored into the periosteum of the tibia as described in the experiments. It was then woven backwards and forwards through the new and old ligamenta patellæ until these formed a solid mass of tendinous tissue, and finally anchored into the patella. The result in this case, as you can see, is entirely satisfactory. The patient now has the full use of his knee and has been able to return to his ordinary occupation.

The technique described in this operation is illustrative of that employed in all the operations in which transplants have been united to bone. It will be observed that great pains have been taken to secure firm adhesion of bone to tendon. The transplants were split and scraped and scarified, and made to fit accurately into long holes in the bone. Years ago we discovered during our study of tendon fixation for infantile paralysis, that, unless these precautions were taken, a solid fixation rarely occurred. On several occasions we had an opportunity to examine into the cause of these failures at a second operation and we found that although the tendons had been laid in a tunnel or trough in the bone, a sufficient amount of areolar tissue had been retained on their surfaces to constitute a sheath and that they slipped in these sheaths sufficiently to produce a complete failure of the operation. In other cases the trough in the bone was so short that, in spite of the scarification of the tendon, the strain ultimately placed upon it was enough to stretch the scar-tissue by which it was united to the bone, and failure resulted. These clinical observations, supported by the experimental finding already described, have led us to lay down the rules that in all operations in which it is intended to unite transplants of the fibrous tissues to bone, the transplants must be laid in the bone for a considerable distance, they must fit the troughs or tunnels snugly, and the surfaces must be sufficiently cleaned and scarified to allow actual contact between the bone and the exposed fibres.

The method described has been applied to a variety of other conditions in which deformities have occurred in joints. For example, we have operated upon two patients suffering from recurring lateral dislocation of the patella. In these patients the patella was prevented from redislocation by free transplants of tendon or fascia passed through holes in the patella and the internal condyle of the femur. Both operations have been quite successful. We have also used the method in four cases of severe hallux valgus, with a view to preventing recurrence of the valgus deformity, which is apt to happen after the ordinary operative procedures. One of these has stood the test for eight years and the others, up to the present,

are equally satisfactory. We have also used transplanted tendon and fascia to prevent the varus deformity which frequently follows astragalectomy for infantile paralysis, and as an assistant in arthrodesis of the mid-tarsal joint in small children. During the past two years we have been experimenting with the method in an attempt to prevent foot-drop in paralysis of the dorsiflexors. The operation has consisted in suspending the fore-part of the foot from the lower end of the tibia by means of transplanted tendon. Up to the present we can report two successful results.

The principle of the method has been applied in a somewhat different manner in recurring dislocation of the shoulder. This condition results from stretching of the scar which forms after the rupture of the ligaments. The ordinary plication of the capsule, or excision of the scar, with suture of the wound so produced, is notoriously uncertain for the simple reason that the success of the operation must depend on the formation of new scar or areolar tissue in the folds of the plication, or in the line of suture. By using a suture of fascia lata, however, one no longer depends upon new connective tissues to increase the strength of the capsule, but places his reliance on the suture itself. If this is woven backwards and forwards across the weak spot in the ligaments, the capsule can be restored to its former efficiency and a functional cure anticipated. The patient whom we are presenting to-night has stood the strain of an ordinary mechanic's occupation for a year and, as you see, has no disability.

The transplantation of the insertion of muscles has always been more or less of a failure owing to the difficulty of getting a stable union of the muscle fibres to the structures to which they are sutured. This is well exemplified in the attempts that have been made to transplant the insertion of the trapezius into the arm in paralysis of the deltoid. We recently did this operation with the modification that we wove fascial sutures into the trapezius muscle and carried them down to holes drilled in the humerus at the insertion of the deltoid. The result is a marked improvement over those obtained from the usual method.

From time to time we have been called upon to deal with patients who have suffered severe injury to the tendons of the forearm. In some of these it was found impossible to bring the severed ends together, owing to the contracture which had occurred in the muscles. In others in which it was possible to draw the ends of the tendon together with sutures, the success has only been partial owing to the ultimate stretching of the fibrous tissue at the point of union. The same can be said of the attempts that have been made to bridge gaps in tendons with pieces of fascia or tubes of fascia where the union of the fascia to the tendon depended on ordinary sutures. Since the introduction of the principle of living sutures these difficulties have been greatly reduced. In our early cases we wove the strips of fascia into the ends of the tendons, much as a sailor splices a rope, but with the addition of the idea of threading the fascial sutures on a needle the procedure has been greatly simplified. Gaps in severed tendons can now be easily bridged, with a certainty that stretching at the line of union cannot occur.

The principle has also been successfully employed in the treatment of congenital ptosis. About eight months ago Dr. W. W. Wright operated on such a patient, using fine living sutures made from fascia lata, and he succeeded in suspending the eyelid from the thick skin of the eye-brow which is moved by the occipitofronta'is muscles, without further incision than that which resulted from the puncture of the needle. As you can see the result in this case is truly splendid, in that the ptosis has been overcome without any disfigurement whatever.

Other conditions to which the method is applicable need only passing mention in this paper. It needs no stretch of the imagination to see its possibilities in the treatment of the various types of visceroptosis, floating kidney, malpositions of the uterus and undescended testis. For ruptured and retracted muscles it provides a certain method of securing healing of the severed fibres or of bridging the gap if the ends cannot be approximated.

We have designedly left to the last the discussion of the surgical field in which the most of our clinical work has been done and upon which we feel that the results of our study will have the greatest influence. Hernia is a condition which frequently fails to respond to surgical treatment. The published records of all well-known clinics show that the number of recurrences after the operative treatment of large ventral hernias, direct inguinal hernias, and old oblique hernias in patients past middle age, is most unsatisfactorily high. This state of affairs, we have great hope, will be materially changed with the introduction of the principle of living sutures. We shall not enter here into the details of the operative treat-

ment, as these will form the basis of another paper, but we shall rest content with a short review of the cases and their treatment, and a report of the results so far obtained. Up to date we have operated on thirty patients. A few of these were suffering from recently acquired direct inguinal hernia but the majority were cases of recurred direct or indirect inguinal hernia, or supposedly inoperable ventral hernia. There was one case of recent indirect inguinal hernia in a man suffering from a complete flaccid paralysis of the abdominal muscles. Beyond the removal of the sacs the treatment in these cases consisted of repairing the weak abdominal wall with living sutures of fascia lata. These sutures were about seven inches long and a quarter of an inch wide. They were threaded upon a curved large-eyed needle and woven into the edges of the surrounding muscles and aponeurosis much as one darns a sock. No attempt was made to drag the structures into which they were woven out of their normal positions, as is so frequently done in the ordinary operations, but simply sufficient tension employed to make the sutures lie flat. Thus the success of the operation depends not upon inducing such structures as the internal oblique muscle or the conjoined tendon to heal to Poupart's ligament, but solely upon the strength of the living suture and upon its firm grip of the surrounding tissues. One case serves to illustrate the value of the method. A soldier was admitted to hospital with a huge ventral hernia resulting from a shell wound which tore away the right upper portion of the abdominal wall, including most of the rectus muscle. When we saw him he had an hernial ring of oval shape which measured seven inches by four. All who saw him agreed that by ordinary methods one could not hope for a cure. Our operation consisted of the removal of the scar and sac, the exposure of the edges of the muscular and aponeurotic ring and the closure of the opening by layers of living sutures which were woven strongly into the surrounding structures and crossed each other as in the weaving of a basket. The result has been most gratifying. As you see the hernia is cured and the abdominal wall is as firm as could be desired.

These operations for hernia have now extended over a period of nearly two years and, up to the present, there has not been a single recurrence. One of the cases suppurated mildly, but after discharging pus for about four weeks healed up without extrusion of the sutures and has remained solid ever since. When one considers that these were all difficult cases, many of which had been operated upon once or twice previously, by first-class surgeons, the value of the principle of living sutures must be apparent. We believe that we have found a method which will reduce the percentage of recurrences to a negligible quantity and greatly widen the field in which operative interference will be of value.

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